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ABSTRACT

Ecosystems are available to educators as interactive units and as such the National Science Education Standards (NSES) and the Excellence in Environmental Education: Guidelines for Learning (EEE) put considerable emphasis on ecosystems. This ERIC Digest describes the NSES and EEE guidelines for grades 5-8 and 9-12 to provide a basic ecosystem framework and includes information on instructional materials, activities, and World Wide Web resources. (YDS)

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When someone asks us where we are from or what we do, most of us mention the town or city where we live, our occupation, where we attended school, or our family heritage. We respond in terms of human communities, cultures, and geopolitical boundaries. We seldom, if ever, describe ourselves in terms of our ecological status in the natural world. We humans have so completely ordered, designed, and defined our physical environs and social milieu that our ecological connections have slipped from consciousness. Perhaps this is why we seem so unaware of our impact on nature and our rapid destruction of natural systems. We simply do not perceive ourselves as being part of the natural order of beings.

All of us live within ecological systems, or *ecosystems*, and through our commerce, food distribution, and use of natural resources we each indirectly participate in the custodianship of many ecosystems worldwide. Ironically, we are simultaneously the most potent forces within most ecosystems, and yet nearly oblivious to the ecological effects of our daily lifestyles. There has never been a time when a deep understanding of ecosystems and our roles within them has been more critical. Indeed, the world's freshwater ecosystems are so degraded that their ability to support plant and animal life, including humans, is viewed by many as being in peril (Revenga, Brunner, Henninger, Kassem, & Payne, 2000). Learning about ecosystems is more than an expected focus in biology classes; it has become a study in survival.

Ecosystems are functional units of interacting abiotic, biotic, and cultural (anthropogenic) components. All natural ecosystems are open systems where energy and matter are transferred in and out through the complex interactions of energy, water, carbon, oxygen, nitrogen, phosphorus, sulfur, and other cycles. Unfortunately, many scientists contend, we humans have disrupted the balance of transfers across ecosystem boundaries. In addition to learning our place within ecosystems, we must learn to become better stewards and managers of ecosystems. A history of the ecosystem concept has been presented by Bocking (1994). Unfortunately, some concepts related to ecosystems—food web, ecological adaptation, carrying capacity, niche—are complex and lead to misconceptions among students (Munson, 1994).

Ecosystems in the Curriculum

Ecosystems receive considerable attention in national curriculum standards and guidelines. Both the *National Science Education Standards* (NSES, National Research Council, 1996) and the *Excellence in Environmental Education: Guidelines for Learning (K-12)* (EEE, North American Association for Environmental Education, 2000) use systems as an organizing concept. Within the *Standards*, the *unifying concepts and processes* for K-12 content standards include "Systems, Order, and Organization", and within the EEE *Guidelines*, one of the four organizing strands is "Knowledge of Environmental Processes and Systems" that includes specific guidelines regarding ecosystems and their components. The *Standards* also include several content standards pertaining to ecosystems in the *Life Science* strand and the *Science in Personal and Social Perspective* strand. Following is a overview of the standards and guidelines specifically relating to ecosystems.

Standards and Guidelines for Grades 5-8

Content Standards (NSES)

- The complementary nature of structure and function within ecosystems.
- All populations living together and the physical factors with which they interact compose an ecosystem.
- Populations of organisms can be categorized by the function they serve in an ecosystem, and food webs identify the relationships among producers, consumers, and decomposers in an ecosystem.
- Energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis. That energy then passes from organism to organism in food webs.
- The number of organisms an ecosystem can support depends on the resources available and abiotic factors.

The Living Environment Guidelines (EEE)

- Define ecosystem and give examples of connections among organisms at this level of organization.
- Summarize how abiotic and biotic components in combination influence the structure of an ecosystem.
- Describe how energy, which enters ecosystems as sunlight, changes form and is transferred in the exchanges (production, consumption, and decomposition) that comprise food webs.

Standards and Guidelines for Grades 9-12

Content Standards (NSES)

- Energy flows through ecosystems in one direction, from photosynthetic organisms to herbivores to carnivores and decomposers.
- Organisms both cooperate and compete in ecosystems. The interrelationships and interdependencies of these organisms may generate ecosystems that are stable for hundreds or thousands of years.
- Human beings live within the world's ecosystems. Increasingly, humans modify ecosystems as a result of population growth, technology, and consumption. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability, and if not addressed, ecosystems will be irreversibly affected.
- The distribution and abundance of organisms and populations in ecosystems are limited by the availability of matter and energy and the ability of the ecosystem to recycle materials.
- Natural ecosystems provide an array of basic processes that affect humans. Those processes include maintenance of the quality of the atmosphere, generation of soils, control of the hydrologic cycle, disposal of wastes, and recycling of nutrients. Humans are changing many of these basic processes, and the changes may be detrimental to humans.

The Living Environment Guidelines (EEE)

- Apply the concepts of ecosystem and ecoregion to organize the multitude of relationships among organisms and environments.
- Explain ecosystem change with respect to variables such as climate change, the introduction of new species, and human impacts; and explain processes such as desertification and soil formation as mechanisms for such change.
- Describe succession in ecosystems and their constituent plant and animal communities.
- Describe how adding a species to, or removing one from, an ecosystem may affect other organisms and the entire system.

There are many additional standards and guidelines that directly or indirectly relate to ecosystems, but this overview provides the basic conceptual framework to be developed through the school curriculum. It should be noted that the framework includes attention both to basic concepts pertaining to ecological systems as well as the impacts of human activity on ecosystem change and stability.

Beyond the Textbook and Standards

As Noss, LaRoe, and Scott (1995) have so convincingly documented, there have been severe declines in the area and natural quality of terrestrial and aquatic ecosystems in all regions of the United States. Habitat loss, ecosystem degradation, and ecosystem fragmentation have led to great losses in biodiversity. Indeed, entire ecosystems are endangered along with individual species. Though management efforts have led to the gradual recovery of some ecosystems, there is a need for citizens to gain a greater sense of their ecological connections and the long-term impacts of human activities.

Schools and individual teachers are responding by developing programs and learning experiences that focus on ecosystems, field study, and

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examinations of human impact through actions and decisions. Tracy and Glaser (1999) described an immersion program in which K-5 students meet all curriculum guidelines through investigating, monitoring, and restoring schoolground habitats and local ecosystems. Lewis (1999) focuses on an analysis of human impacts through ecosystem surveys that engage students in formulating and testing hypotheses about human impacts.

Freeman (2002) describes a unique approach to studying the human impact on ecosystems through ongoing study of an artificial aquatic ecosystem by students in grades 7 through 12. She describes activities that are woven into the curriculum of integrated science, biology, chemistry, and physics over a six year period.

Another curriculum approach that combines study of ecosystems with consideration of human impacts and decision making is offered by the Forest Service Employees for Environmental Ethics (2000). Their Secret Forest Experience Curriculum is designed for middle school students and engages students in five science-based projects related to ecosystems of western U. S. forests. The materials are available in both English and Spanish.

Finally, Brodie (1995) offers background and activities related to a unique ecosystem, the Great Basin of the western United States, that draws attention to web of life within deserts. This unit of study is appropriate for upper elementary and middle school students, and includes both a historical perspective and visions of future options in terms of human impact on this arid ecosystem.

Reaching Beyond the Science Classroom

To supplement the traditional content on ecosystems in science classes, some groups have developed instructional materials and activities that integrate ecosystem concepts with a range of topics and subjects. Following are selected examples of materials that are available to teachers.

Adams, M., Brickell, R., & Hanophy, W. (Senior Eds.). (1995). *Ecosystem matters: Activity and resource guide for environmental educators*. Washington, DC: U. S. Department of Agriculture. [ED 403 116]

> classroom teachers, nature camp instructors, scout leaders, forest rangers, naturalists, and others who are helping learners make conscious decision that lead to the long-term stewardship of natural resources. This guide was designed to supplement existing courses and programs concerning ecological matters, and the activities focus on ecosystem management. The interdisciplinary activities relate to topics in social studies, drama, language arts, geography, history, math, physical education, and science, and the activities are categorized by grades K-3 (13 activities), grades 4-5 (20 activities), grades 6-8 (25 activities), and grades 9-12 (13 activities.

Lewis, J. (1999). People, growth, and endangered ecosystems: Exercises in biodiversity, grades 6-12. Tallahassee: Florida State Department of Environmental Protection. [ED 434 013]

> This document features interdisciplinary activities that combine the study of biology with music, art, language arts and social studies. The activities are aimed at students in middle school through the first two years of high school. All activities can be conducted in the classroom or outdoors near the school.

Selected World Wide Web Resources

Living Things: Habitats and Ecosystems
A resource of the Franklin Institute
http://www.fi.edu/tfi/units/life/habitat/habitat.html

Earth on Edge: Ecosystems
A Web resource associated with Bill Moyers Reports on PBS that examines the status of the world's ecosystems
http://www.pbs.org/earthonedge/ecosystems/index.html

Exploring Ecosystems Online
An electronic field trip for grades 7-12 provided by the Smithsonian Institution's National Museum of Natural History
http://www.bsu.edu/teachers/academy/ecosystems/

Ecosystems of Our World
An interactive Think Quest resource featuring ten different ecosystems
http://library.thinkquest.org/11353/ecosystems.htm

Freshwater Ecosystems
And extensive directory of Web resources and lesson plans on aquatic ecosystems in Canada and the United States
http://www.eagle.ca/~matink/themes/Biomes/watereco.html

Ecosystems
A Learning Web resource provided by the U.S. Geological Survey
http://interactive2.usgs.gov/learningweb/explorer/topic_eco_links.asp

Backyard Science: How Ecosystems Work
Online teaching guide for an activity suitable for students in grades 5-12.
http://www.pbs.org/safarchive/5_cool/galapagos/g52e_ecosystems.html

Ecosystems
A lesson plan from Discovery.com suitable for students in grades 6-8.
http://school.discovery.com/lessonplans/programs/yosemite/

Finding Information in the ERIC Database

There are many records in the ERIC Database pertaining to ecosystems, but it takes a little searching to find them. The term *ecosystem* is not used to index records in ERIC, so it is best to search using *ecology* as a Descriptor, combined with ecosystem or ecosystems as keywords. You can narrow your search by combining these terms with one or more of the following Descriptors: *teaching methods, instructional materials, experiential learning, hands on science, environmental education*, or similar terms. You can further narrow your search by using education level Descriptors, such as *elementary education, middle schools, intermediate grades*, or *junior high schools*, or individual grade levels. You can search the database on the Web at http://ericir.syr.edu/Eric/adv_search.shtml.

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